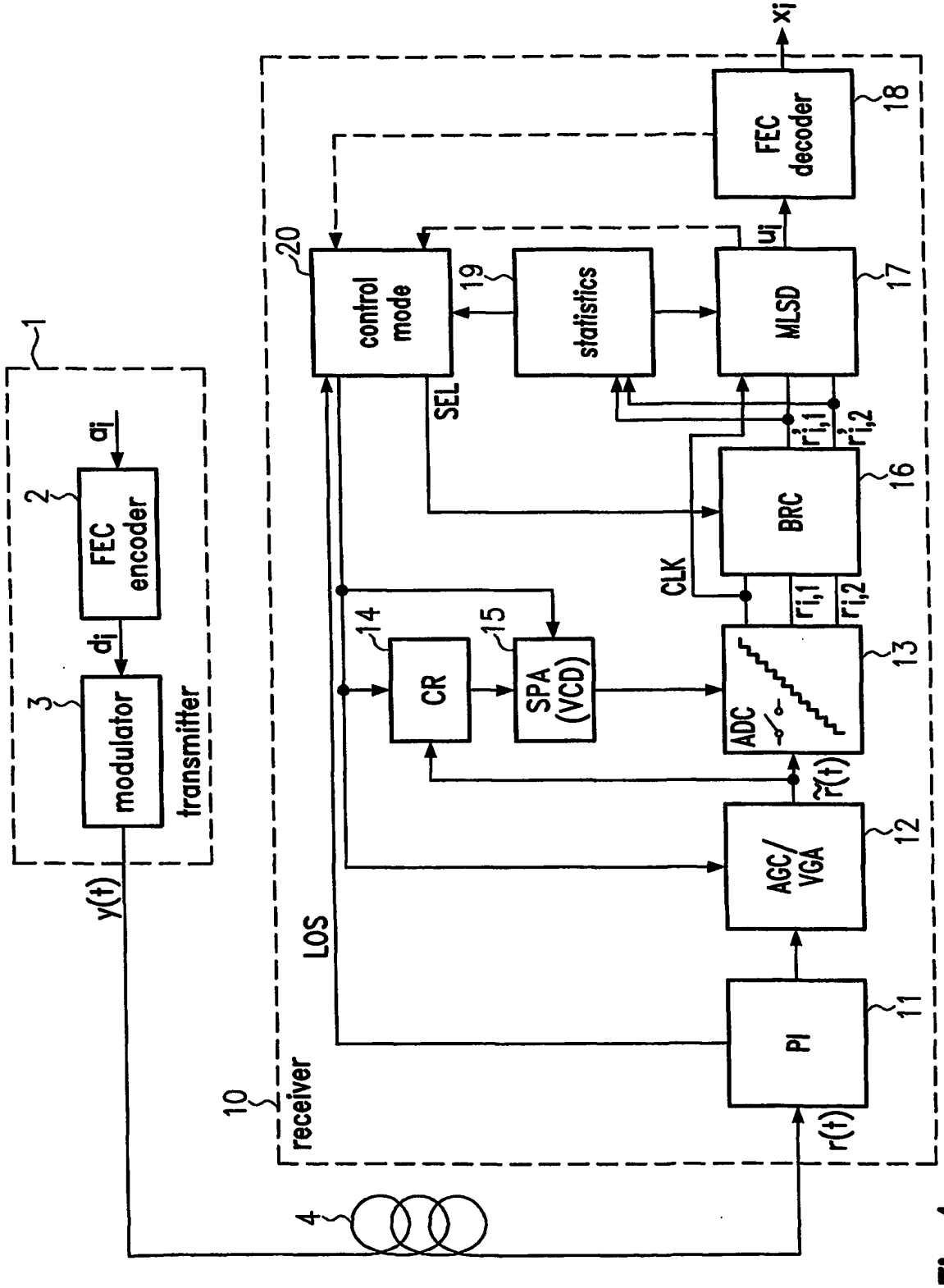

xi
FEC decoder
18
ui
control mode
20
19
statistics
MLSD
17
SEL
$r'_{i,1}$
$r'_{i,2}$
BRC
16
CLK
$r_{i,1}$
$r_{i,2}$
14
15
CR
SPA (VCD)
ADC
13
$\tilde{r}(t)$
AGC/ VGA
12
LOS
PI
11
r(t)
10
receiver
1
di
2
FEC encoder
di
3
modulator
transmitter
y(t)
4

Fig.1

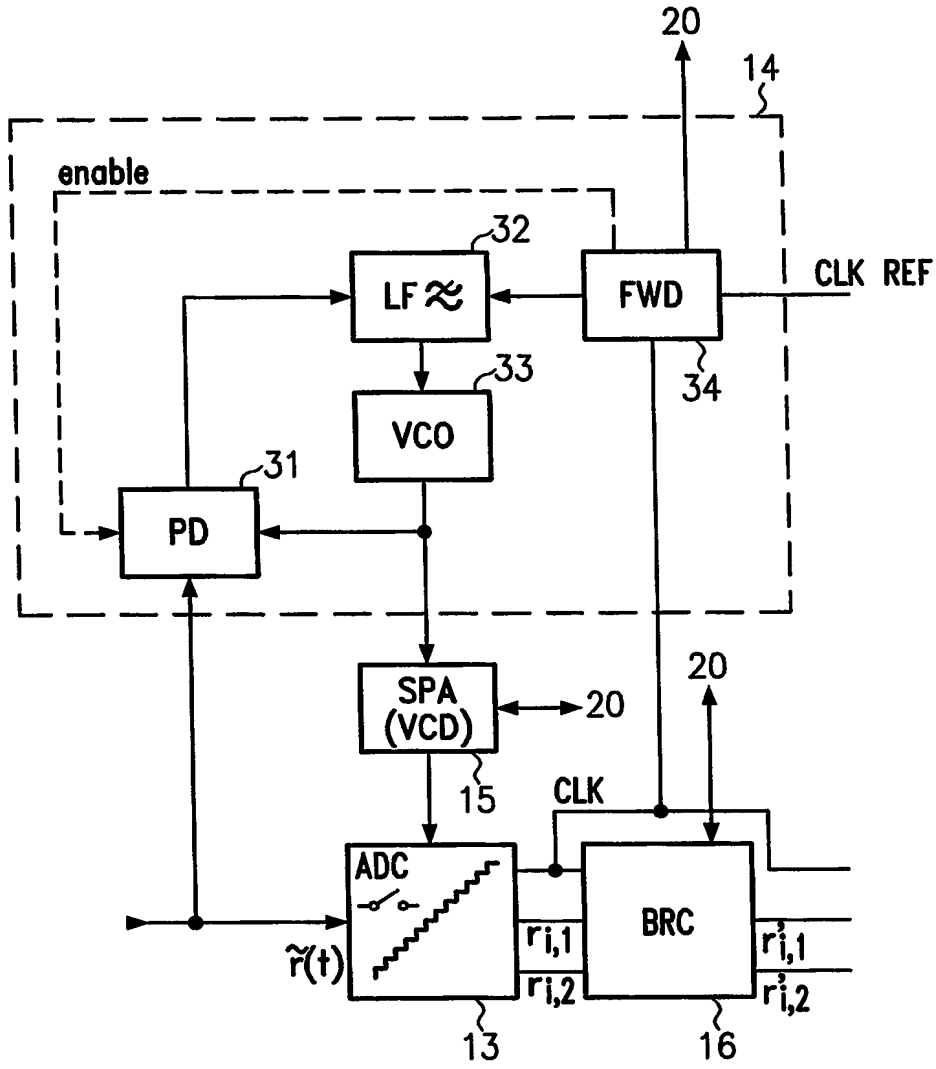

20
14
enable
32
LF
FWD
CLK REF
33
34
VCO
31
PD
SPA
(VCD)
20
20
15
CLK
ADC
BRC
$\tilde{r}(t)$
$r_{i,1}$
$r_{i,2}$
$r'_{i,1}$
$r'_{i,2}$
13
16

Fig.2

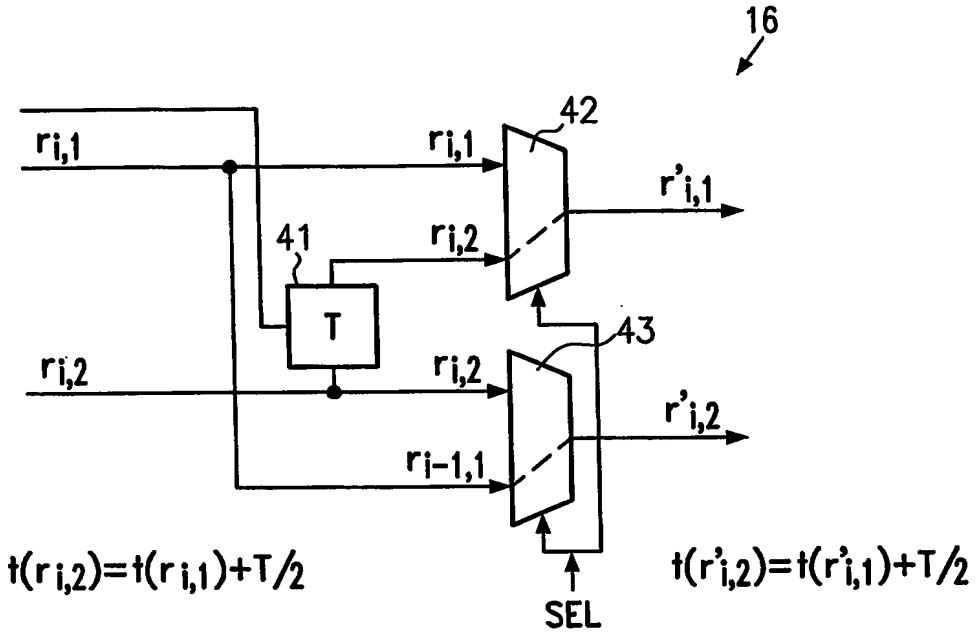

16
42
ri,1
ri,1
r'i,1
41
ri,2
T
43
ri,2
ri,2
r'i,2
ri-1,1
t(ri,2)=t(ri,1)+T/2
t(r'i,2)=t(r'i,1)+T/2
SEL

Fig.3

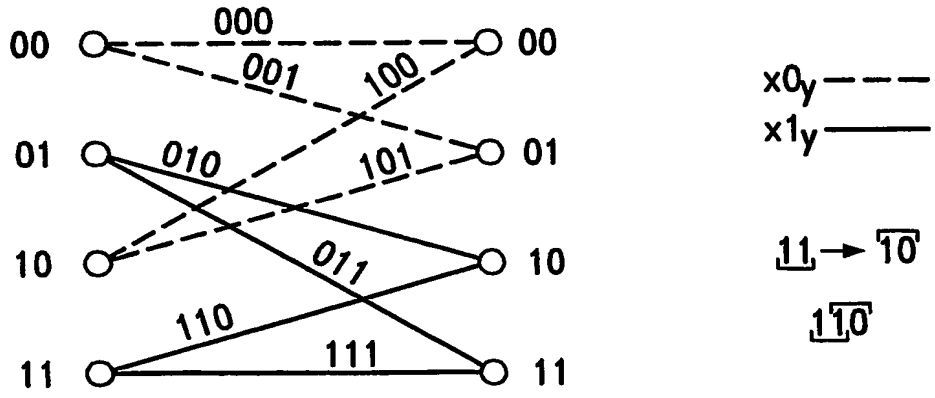
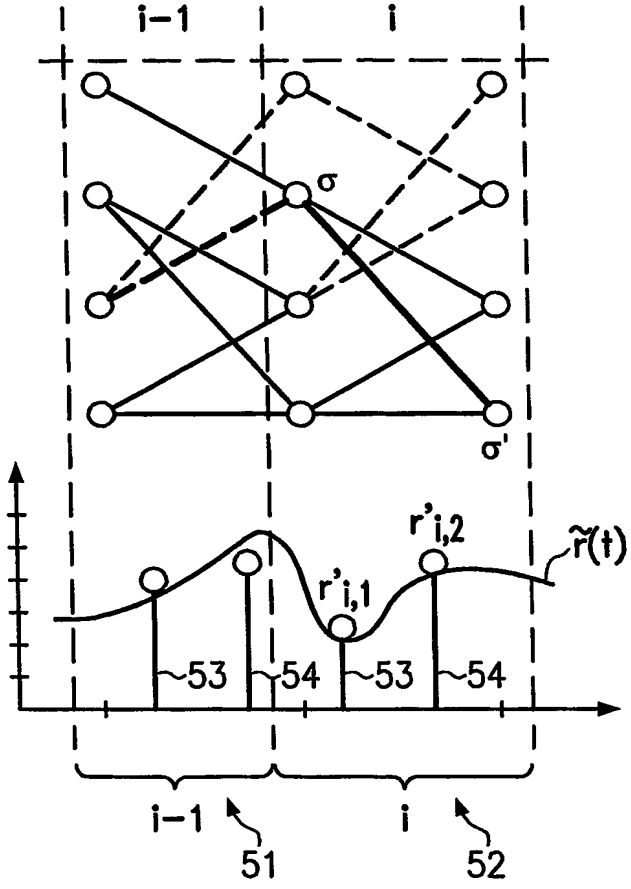

00
01
10
11
000
001
100
010
101
011
110
111
00
01
10
11
x0y
x1y
11 → 10
110
ISI-Trellis, M=2

Fig.4



Brauch–Metric

$$BM_{tot}(\underline{b},r_1,r_2) = BM(\underline{b},r_1) + BM(\underline{b},r_2)$$

$$BM_{tot}(\underline{b},r_1,r_2) = BM_1(\underline{b},r_1) + BM_2(\underline{b},r_1,r_2)$$

$$BM_{tot}(\underline{b},r_1,r_2) = BM(\underline{b},r_1,r_2)$$

$$BM_{tot}(\underline{b},r_1,r_2) = BM_1(\underline{b},r_1) + BM_2(\underline{b},R(r_1),r_2)$$

Fig.5

channel state **b**	quantized data r_1 or r_2							
	0	1	2	3	4	5	6	7
b(0)=000	f(0,0)	f(0,1)	f(0,2)	f(0,3)	f(0,4)	f(0,5)	f(0,6)	f(0,7)
b(1)=001	f(1,0)	f(1,1)	f(1,2)	f(1,3)	f(1,4)	f(1,5)	f(1,6)	f(1,7)
b(2)=010	f(2,0)	f(2,1)	f(2,2)	f(2,3)	f(2,4)	f(2,5)	f(2,6)	f(2,7)
b(3)=011	f(3,0)	f(3,1)	f(3,2)	f(3,3)	f(3,4)	f(3,5)	f(3,6)	f(3,7)
b(4)=100	f(4,0)	f(4,1)	f(4,2)	f(4,3)	f(4,4)	f(4,5)	f(4,6)	f(4,7)
b(5)=101	f(5,0)	f(5,1)	f(5,2)	f(5,3)	f(5,4)	f(5,5)	f(5,6)	f(5,7)
b(6)=110	f(6,0)	f(6,1)	f(6,2)	f(6,3)	f(6,4)	f(6,5)	f(6,6)	f(6,7)
b(7)=111	f(7,0)	f(7,1)	f(7,2)	f(7,3)	f(7,4)	f(7,5)	f(7,6)	f(7,7)

61

62

63

Fig.6

61

channel state $\underline{b}$	quantized data r_1 or r_2							
	0	1	2	3	4	5	6	7
$\underline{b}(0)$	BM(0,0)	BM(0,1)	BM(0,2)	BM(0,3)	BM(0,4)	BM(0,5)	BM(0,6)	BM(0,7)
$\underline{b}(1)$	BM(1,0)	BM(1,1)	BM(1,2)	BM(1,3)	BM(1,4)	BM(1,5)	BM(1,6)	BM(1,7)
$\underline{b}(2)$	BM(2,0)	BM(2,1)	BM(2,2)	BM(2,3)	BM(2,4)	BM(2,5)	BM(2,6)	BM(2,7)
$\underline{b}(3)$	BM(3,0)	BM(3,1)	BM(3,2)	BM(3,3)	BM(3,4)	BM(3,5)	BM(3,6)	BM(3,7)
$\underline{b}(4)$	BM(4,0)	BM(4,1)	BM(4,2)	BM(4,3)	BM(4,4)	BM(4,5)	BM(4,6)	BM(4,7)
$\underline{b}(5)$	BM(5,0)	BM(5,1)	BM(5,2)	BM(5,3)	BM(5,4)	BM(5,5)	BM(5,6)	BM(5,7)
$\underline{b}(6)$	BM(6,0)	BM(6,1)	BM(6,2)	BM(6,3)	BM(6,4)	BM(6,5)	BM(6,6)	BM(6,7)
$\underline{b}(7)$	BM(7,0)	BM(7,1)	BM(7,2)	BM(7,3)	BM(7,4)	BM(7,5)	BM(7,6)	BM(7,7)

62

64

$$BM_{tot}(\underline{b},r_1,r_2) = BM(\underline{b},r_1)+BM(\underline{b},r_2)$$

Fig.7

channel state $\underline{b}$	quantized data r_1				
	0	...	r_1	...	7
$\underline{b}_0$=000	$BM_1(0,0)$	...	$BM_1(0,r_1)$	...	$BM_1(0,7)$
...	...		...		...
$\underline{b}_s$	$BM_1(s,0)$	...	$BM_1(s,r_1)$	...	$BM_1(s,7)$
...	...		...		...
$\underline{b}_7$=111	$BM_1(7,0)$	...	$BM_1(7,r_1)$	...	$BM_1(7,7)$

65, 62, 66

Fig.8

channel state $\underline{b}$	quantized data r_2, BM_2 conditioned on r_1=1				
	0	...	r_2	...	7
$\underline{b}_0$=000	$BM_2(0,r_1,0)$	...	$BM_2(0,r_1,r_2)$	...	$BM_2(0,r_1,7)$
...	...		...		...
$\underline{b}_s$	$BM_2(s,r_1,0)$	...	$BM_2(s,r_1,r_2)$	...	$BM_2(s,r_1,7)$
...	...		...		...
$\underline{b}_7$=111	$BM_2(7,r_1,0)$	...	$BM_2(7,r_1,r_2)$	...	$BM_2(7,r_1,7)$

67, 62, 68, 69

$$BM_{tot}(\underline{b},r_1,r_2) = BM_1(\underline{b},r_1) + BM_2(\underline{b},r_1,r_2)$$

Fig.9

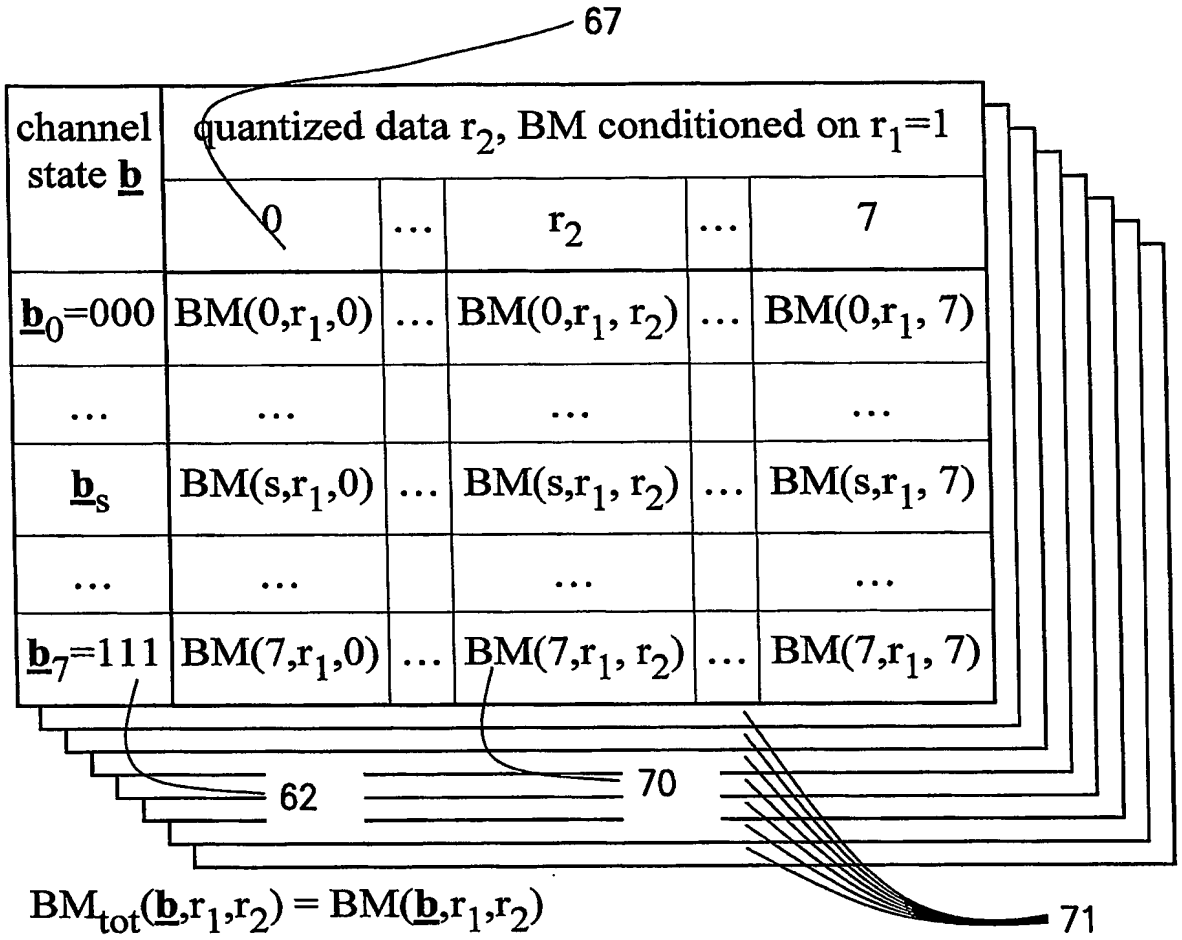
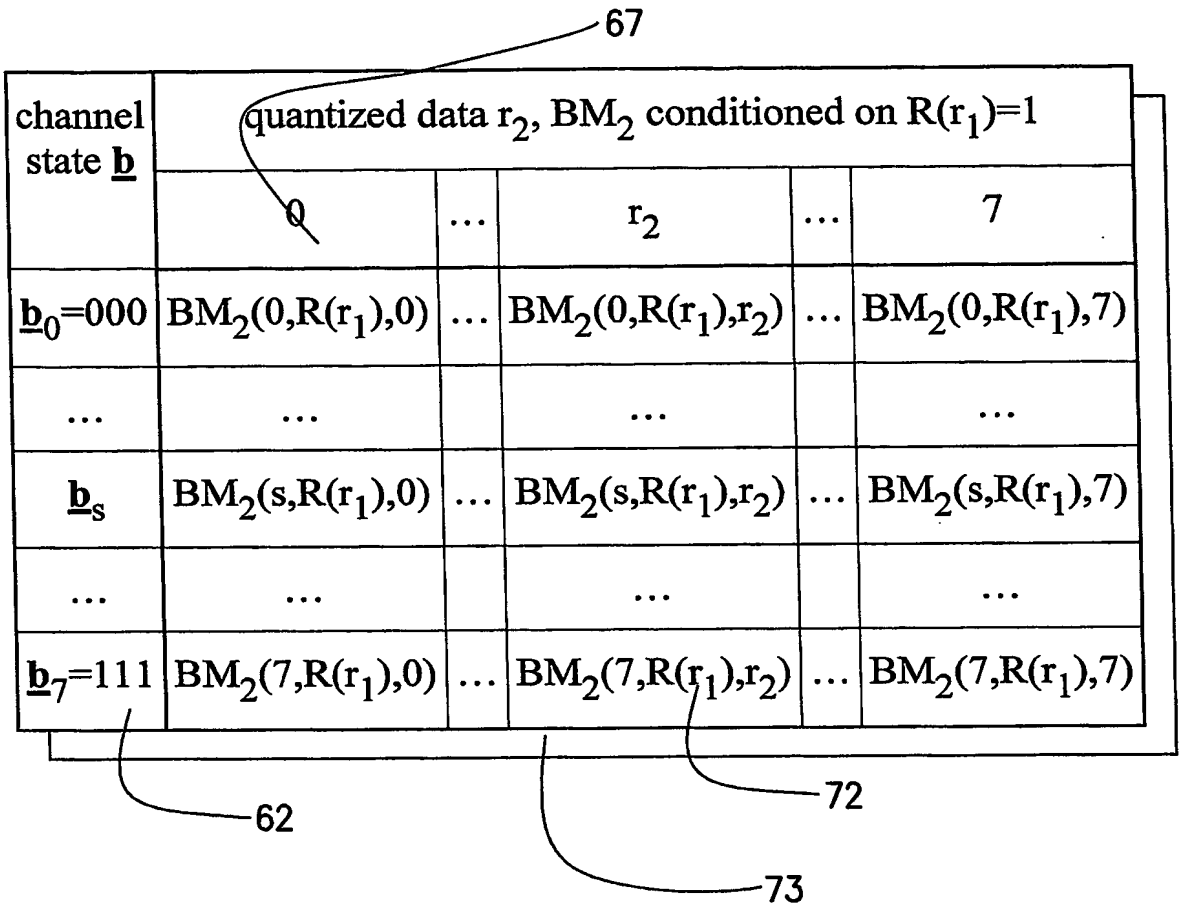

67
channel state $\underline{b}$
quantized data r_2, BM conditioned on r_1=1
0
...
r_2
...
7
$\underline{b}_0$=000
BM(0,r_1,0)
BM(0,r_1, r_2)
BM(0,r_1, 7)
$\underline{b}_s$
BM(s,r_1,0)
BM(s,r_1, r_2)
BM(s,r_1, 7)
$\underline{b}_7$=111
BM(7,r_1,0)
BM(7,r_1, r_2)
BM(7,r_1, 7)
62
70
71
$BM_{tot}(\underline{b},r_1,r_2) = BM(\underline{b},r_1,r_2)$

Fig.10



$$BM_{tot}(\underline{b},r_1,r_2) = BM_1(\underline{b},r_1)+BM_2(\underline{b},R(r_1),r_2)$$

Fig.11

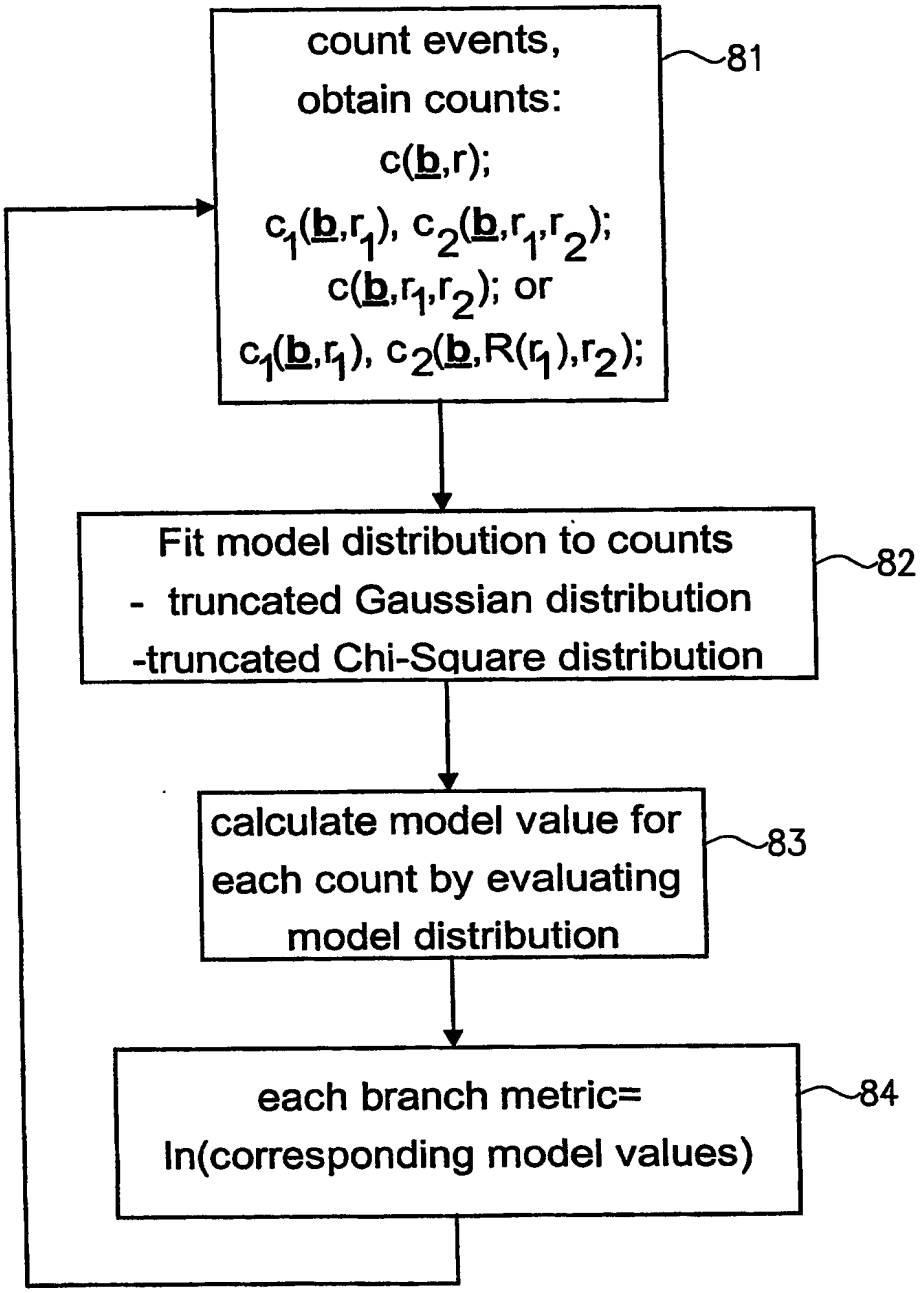

count events,
obtain counts:
c(b,r);
$c_1(\underline{b},r_1)$, $c_2(\underline{b},r_1,r_2)$;
$c(\underline{b},r_1,r_2)$; or
$c_1(\underline{b},r_1)$, $c_2(\underline{b},R(r_1),r_2)$;
81
Fit model distribution to counts
- truncated Gaussian distribution
-truncated Chi-Square distribution
82
calculate model value for each count by evaluating model distribution
83
each branch metric=
ln(corresponding model values)
84

Fig.12

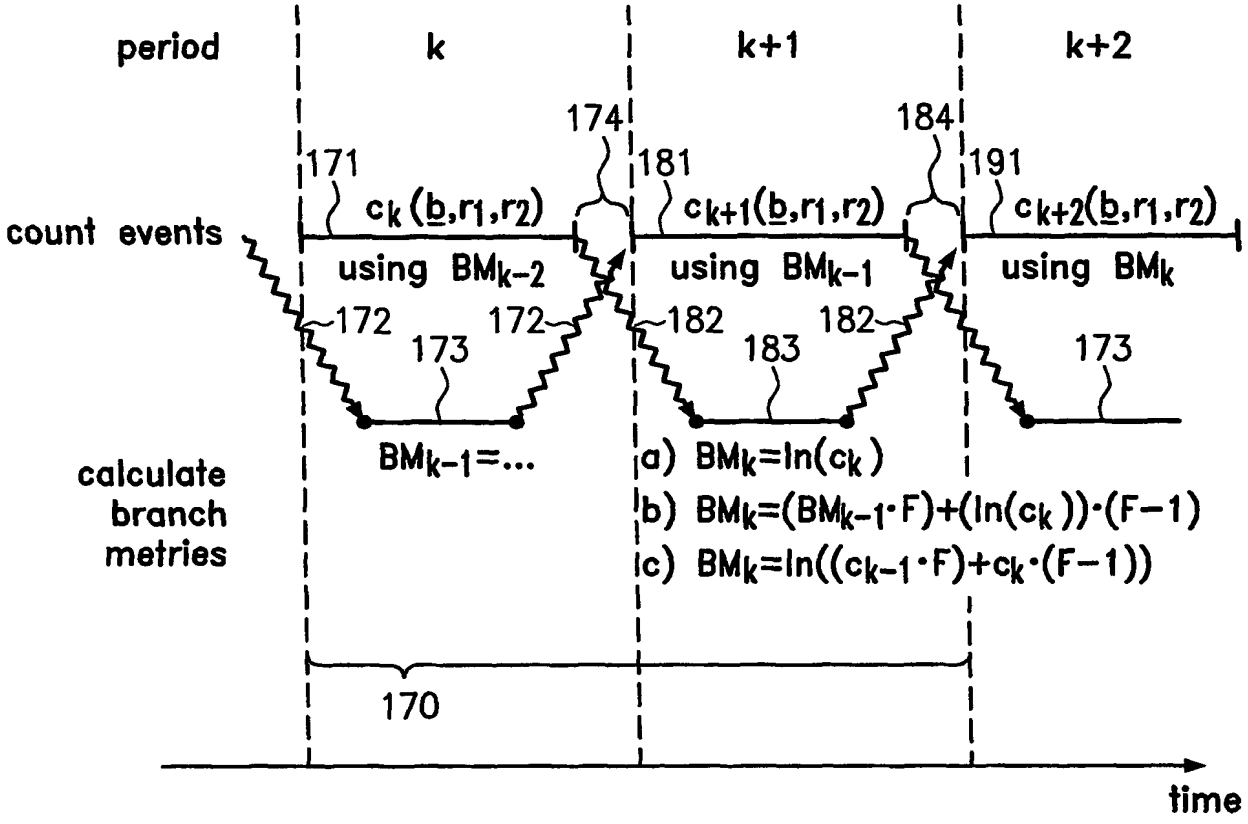

period
k
k+1
k+2
174
184
171
181
191
count events
$c_k(\underline{b},r_1,r_2)$
$c_{k+1}(\underline{b},r_1,r_2)$
$c_{k+2}(\underline{b},r_1,r_2)$
using BM_{k-2}
using BM_{k-1}
using BM_k
172
172
182
182
173
183
173
calculate branch metries
BM_{k-1}=...
a) $BM_k=\ln(c_k)$
b) $BM_k=(BM_{k-1}\cdot F)+(\ln(c_k))\cdot(F-1)$
c) $BM_k=\ln((c_{k-1}\cdot F)+c_k\cdot(F-1))$
170
time

Fig.13

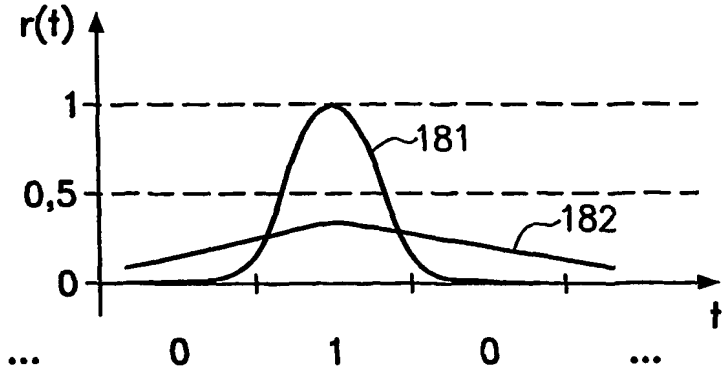

r(t)
1
0,5
0
181
182
t
...
0
1
0
...

Fig.14

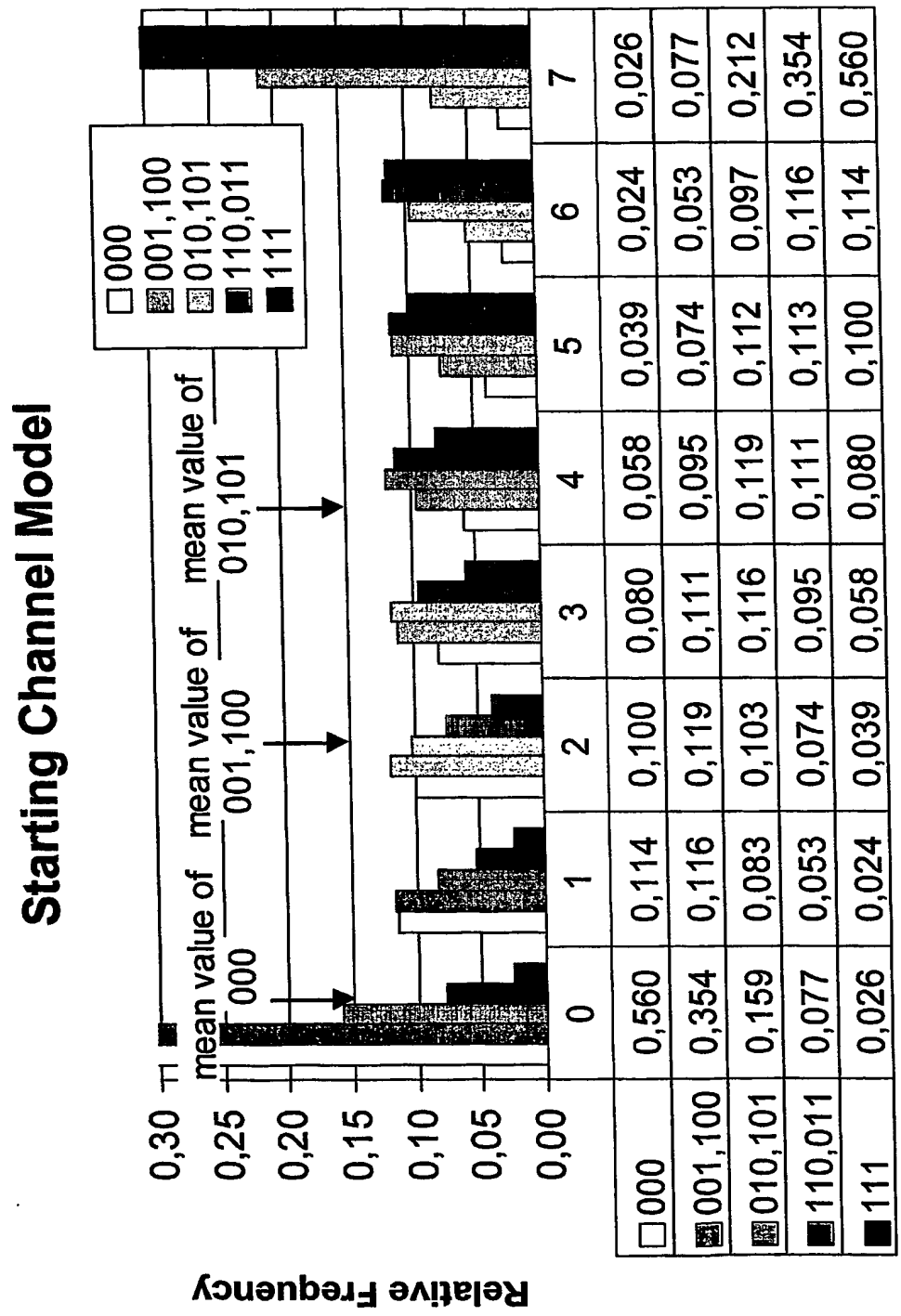

Starting Channel Model
mean value of 000
mean value of 001,100
mean value of 010,101
000
001,100
010,101
110,011
111
0,30
0,25
0,20
0,15
0,10
0,05
0,00
Relative Frequency
Quantized Sample Value
0 1 2 3 4 5 6 7
000 0,560 0,114 0,100 0,080 0,058 0,039 0,024 0,026
001,100 0,354 0,116 0,119 0,111 0,095 0,074 0,053 0,077
010,101 0,159 0,083 0,103 0,116 0,119 0,112 0,097 0,212
110,011 0,077 0,053 0,074 0,095 0,111 0,113 0,116 0,354
111 0,026 0,024 0,039 0,058 0,080 0,100 0,114 0,560

Fig.15

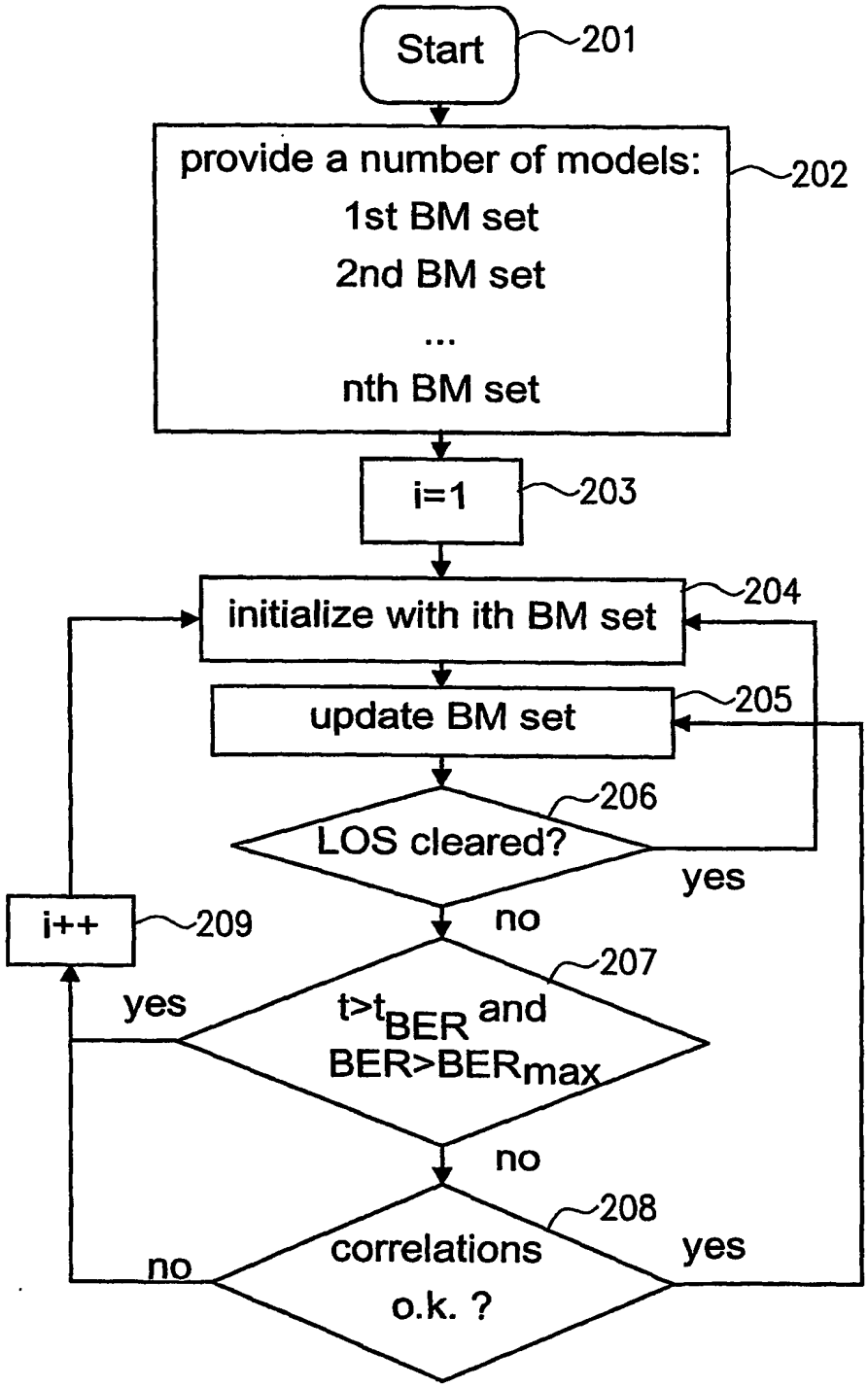

Start
201
provide a number of models:
1st BM set
2nd BM set
...
nth BM set
202
i=1
203
initialize with ith BM set
204
update BM set
205
LOS cleared?
206
yes
no
i++
209
t>t_BER and
BER>BER_max
207
yes
no
correlations
o.k. ?
208
no
yes

Fig.16

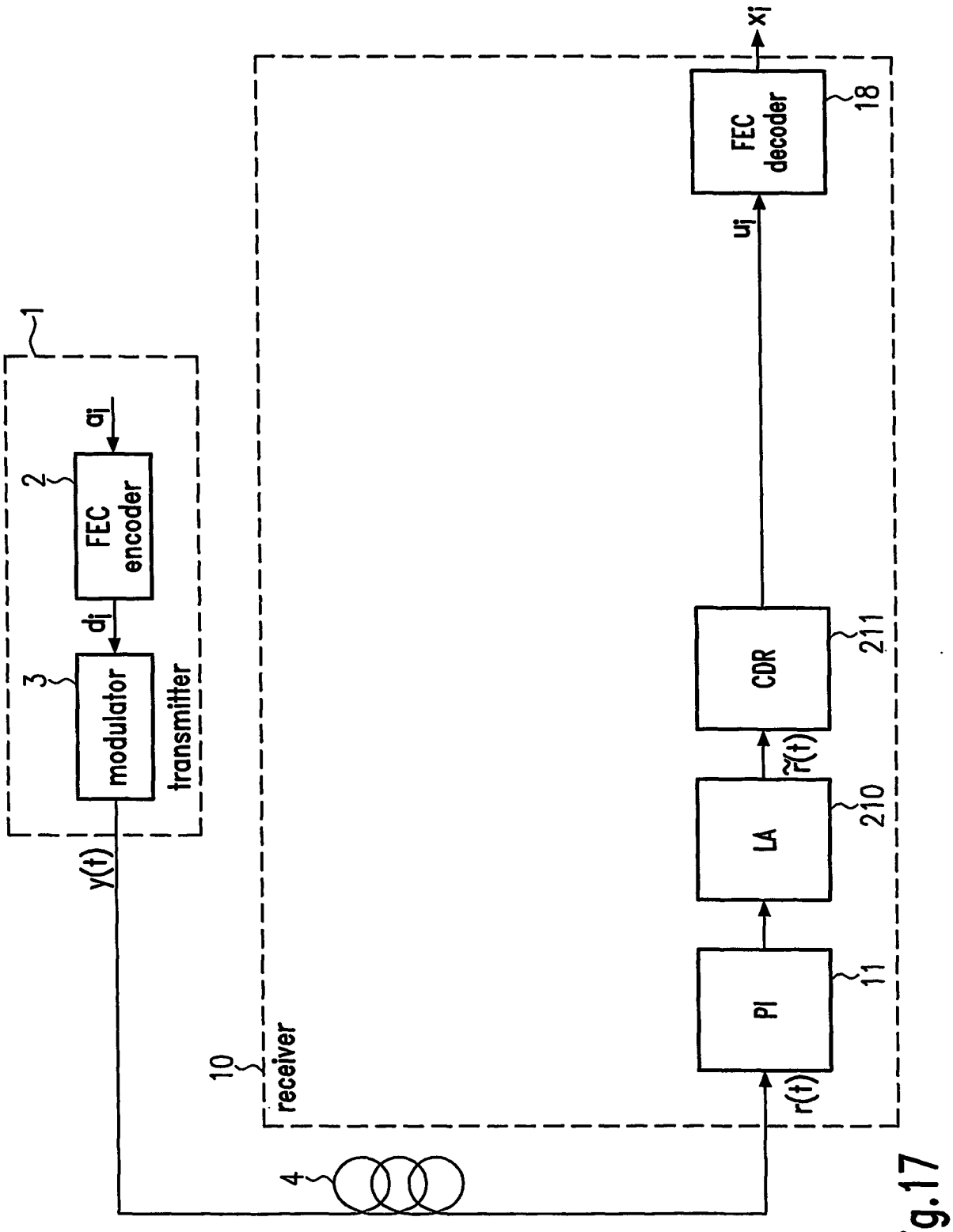

1
transmitter
2
FEC encoder
3
modulator
aj
dj
y(t)
4
10
receiver
PI
11
LA
210
CDR
211
r(t)
r̃(t)
FEC decoder
18
uj
xj

Fig.17